

What is claimed is:

1. A piezoelectric/electrostrictive element comprising:  
a substantially trapezoidal laminate having narrower and  
5 wider surfaces lying substantially in parallel to each other and first  
and second surfaces opposed to each other between the narrower  
and wider surfaces, the first and second surfaces being inclined at  
given angles to one of the narrower and wider surfaces, said  
laminate being made up of a plurality of piezoelectric/electrostrictive  
10 layers and a plurality of internal electrodes each of which is disposed  
between adjacent two of the piezoelectric/electrostrictive layers, the  
internal electrodes being broken up into a first and a second group,  
each of the first group internal electrodes lying over one of the  
second group internal electrodes through one of the  
15 piezoelectric/electrostrictive layers;  
a first external electrode formed on the first surface of said  
laminate, said first external electrodes being coupled to the first  
group internal electrodes; and  
a second external electrode formed on the second surface of  
20 said laminate, said second external electrodes being coupled to the  
second group internal electrodes.
2. A piezoelectric/electrostrictive element as set forth in claim 1,  
wherein said piezoelectric/electrostrictive layers are decreased in  
25 width gradually in one of directions of lamination.

3. A piezoelectric/electrostrictive element as set forth in claim 1, wherein the external electrode layers formed on said side surface portions extend along the wider surface of said laminate.

5 4. A piezoelectric/electrostrictive element as set forth in claim 3, wherein a width of a portion of said first external electrode layer extending on said wider surface is greater than that of a portion of said second external electrode layer extending on a side of said wider surface.

10 5. A piezoelectric/electrostrictive element as set forth in claim 1, wherein either of surfaces in said directions of lamination is the piezoelectric/electrostrictive layer.

15 6. A piezoelectric/electrostrictive element as set forth in claim 1, wherein the number of said internal electrode layers connecting with said first external electrode layer is identical with that of said internal electrode layers connecting with said second external electrode layer.

20 7. A piezoelectric/electrostrictive element as set forth in claim 1, wherein the number of said internal electrode layers connecting with said first external electrode layer is different from that of said internal electrode layers connecting with said second external  
25 electrode layer.

8. A piezoelectric/electrostrictive device in which a piezoelectric/electrostrictive element includes a substantially trapezoidal laminate having narrower and wider surfaces lying substantially in parallel to each other and first and second surfaces opposed to each other between the narrower and wider surfaces, the first and second surfaces being inclined at given angles to one of the narrower and wider surfaces, said laminate being made up of a plurality of piezoelectric/electrostrictive layers and a plurality of internal electrodes each of which is disposed between adjacent two of the piezoelectric/electrostrictive layers, the internal electrodes being broken up into a first and a second group, each of the first group internal electrodes lying over one of the second group internal electrodes through one of the piezoelectric/electrostrictive layers; a first external electrode formed on the first surface of said laminate, said first external electrodes being coupled to the first group internal electrodes; and a second external electrode formed on the second surface of said laminate, said second external electrodes being coupled to the second group internal electrodes and in which said piezoelectric/electrostrictive element is bonded to a surface of a movable plate on a side of the narrower surface of said laminate.

9. A piezoelectric/electrostrictive device as set forth in claim 8, wherein said piezoelectric/electrostrictive element is bonded to said movable plate by adhesive disposed within a gap defined by said first surface, said second surface, and said movable plate.

10. A piezoelectric/electrostrictive device as set forth in claim 9, characterized in that a structure made up of said piezoelectric/electrostrictive element and said adhesive is trapezoidal or rectangular parallelepipedic.

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11. A piezoelectric/electrostrictive device as set forth in claim 8, wherein the first and second external electrode layers formed on said first and second surfaces extend on the wider surface of said laminate.

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12. A piezoelectric/electrostrictive device as set forth in claim 8, wherein said piezoelectric/electrostrictive element is bonded only to one surface of said movable plate.

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13. A piezoelectric/electrostrictive device as set forth in claim 8, wherein said piezoelectric/electrostrictive elements are bonded to both surfaces of the movable plate so as to hold the movable plate therebetween.

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14. A piezoelectric/electrostrictive device as set forth in claim 8, wherein said movable plate is made of an insulating material.

15. A piezoelectric/electrostrictive device as set forth in claim 8, wherein said movable plate is made of a conductive material.

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16. A piezoelectric/electrostrictive device as set forth in claim 15,

wherein said movable plate communicates with one of the external electrode layers of said piezoelectric/electrostrictive element.

17. A piezoelectric/electrostrictive device as set forth in claim 16,  
5 wherein said adhesive has conductivity, and wherein said movable plate communicates with one of the external electrode layers of said piezoelectric/electrostrictive elements through the adhesive.

18. A piezoelectric/electrostrictive device in which a pair of  
10 piezoelectric/electrostrictive elements each includes a substantially trapezoidal laminate having narrower and wider surfaces lying substantially in parallel to each other and first and second surfaces opposed to each other between the narrower and wider surfaces, the first and second surfaces being inclined at given angles to one of the  
15 narrower and wider surfaces, said laminate being made up of a plurality of piezoelectric/electrostrictive layers and a plurality of internal electrodes each of which is disposed between adjacent two of the piezoelectric/electrostrictive layers, the internal electrodes being broken up into a first and a second group, each of the first  
20 group internal electrodes lying over one of the second group internal electrodes through one of the piezoelectric/electrostrictive layers; a first external electrode formed on the first surface of said laminate, said first external electrodes being coupled to the first group internal electrodes; and a second external electrode formed on the second  
25 surface of said laminate, said second external electrodes being coupled to the second group internal electrodes and in which said

piezoelectric/electrostrictive elements are bonded to each other on sides of the respective narrower surfaces of said laminates.

19. A piezoelectric/electrostrictive device as set forth in claim 8,  
5 wherein said first and second external electrode layers are connected to a voltage applying circuit.

20. A piezoelectric/electrostrictive device as set forth in claim 8,  
10 wherein said first and second external electrode layers are connected to a voltage detecting circuit.

21. A method of producing a piezoelectric/electrostrictive element comprising the steps of:

15 a first step of preparing a ceramic substrate having a given width;

a second step of forming a laminate on said ceramic substrate, said laminate being made up of a first and a second portions laid to overlap each other, the first portion being made by the steps of::

20 printing a first electrode layer and a second electrode layer on said ceramic substrate which are disposed at a given interval away from each other;

forming a piezoelectric/electrostrictive layer using a piezoelectric/electrostrictive paste on the first and second electrode  
25 layers so as to cover portions of the first and second electrode layers other than edge portions thereof lying outward in a widthwise

direction of said ceramic substrate;

forming a first electrode layer on an upper surface and a side surface of the piezoelectric/electrostrictive layer so as to establish an electric connection only with the first electrode layer lying

5 immediately beneath the first electrode layer formed in this step,

said second portion being made by performing the following set of steps a given number of times which include:

forming a piezoelectric/electrostrictive layer using a piezoelectric/electrostrictive paste on an uppermost one of the first  
10 electrode layers, the piezoelectric/electrostrictive layer formed in this step having a width smaller than that of the piezoelectric/electrostrictive layer lying immediately beneath the piezoelectric/electrostrictive layer formed in this step;

forming a second electrode layer on an upper surface and a  
15 side surface of an uppermost one of the piezoelectric/electrostrictive layers so as to establish an electric connection only with the second electrode layer lying immediately beneath the second electrode layer formed in this step;

forming a piezoelectric/electrostrictive layer using a  
20 piezoelectric/electrostrictive paste on an uppermost one of the second electrode layers, the piezoelectric/electrostrictive layer formed in this step having a width smaller than that of the piezoelectric/electrostrictive layer lying immediately beneath the piezoelectric/electrostrictive layer formed in this step;

25 forming a first electrode layer on an upper surface and a side surface of an uppermost one of the piezoelectric/electrostrictive

layers so as to establish an electric connection only with the first electrode layer lying immediately beneath the first electrode layer formed in this step; and

- a third step of firing said ceramic substrate and said  
5 laminate at a given temperature; and  
a fourth step of removing said laminate from said ceramic substrate.

22. A method of producing a piezoelectric/electrostrictive  
10 element as set forth in claim 21, wherein a width of the second electrode layer disposed on said ceramic substrate at a given interval away from said first electrode layer in an opposed direction is greater than that of the first electrode layer.

15 23. A method of producing a piezoelectric/electrostrictive element as set forth in claim 21, wherein a film is formed on said ceramic substrate which disappears upon firing.

24. A method of producing a piezoelectric/electrostrictive device  
20 in which a piezoelectric/electrostrictive element includes a substantially trapezoidal laminate having narrower and wider surfaces lying substantially in parallel to each other and first and second surfaces opposed to each other between the narrower and wider surfaces, the first and second surfaces being inclined at given  
25 angles to one of the narrower and wider surfaces, said laminate being made up of a plurality of piezoelectric/electrostrictive layers



and a plurality of internal electrodes each of which is disposed between adjacent two of the piezoelectric/electrostrictive layers, the internal electrodes being broken up into a first and a second group, each of the first group internal electrodes lying over one of the  
5 second group internal electrodes through one of the piezoelectric/electrostrictive layers; a first external electrode formed on the first surface of said laminate, said first external electrodes being coupled to the first group internal electrodes; and a second external electrode formed on the second surface of said laminate,  
10 said second external electrodes being coupled to the second group internal electrodes, and the piezoelectric/electrostrictive element is bonded to a surface of a movable plate by adhesive.

25. A method of producing a piezoelectric/electrostrictive device  
15 as set forth in claim 24, wherein said piezoelectric/electrostrictive elements are bonded to surfaces of said movable plate through adhesive.

26. A method of producing a piezoelectric/electrostrictive device  
20 in which a pair of piezoelectric/electrostrictive elements each include a substantially trapezoidal laminate having narrower and wider surfaces lying substantially in parallel to each other and first and second surfaces opposed to each other between the narrower and wider surfaces, the first and second surfaces being inclined at  
25 given angles to one of the narrower and wider surfaces, said laminate being made up of a plurality of piezoelectric/electrostrictive

layers and a plurality of internal electrodes each of which is disposed between adjacent two of the piezoelectric/electrostrictive layers, the internal electrodes being broken up into a first and a second group, each of the first group internal electrodes lying over one of the

5 second group internal electrodes through one of the piezoelectric/electrostrictive layers; a first external electrode formed on the first surface of said laminate, said first external electrodes being coupled to the first group internal electrodes; and a second external electrode formed on the second surface of said laminate,

10 said second external electrodes being coupled to the second group internal electrodes, and the piezoelectric/electrostrictive elements are bonded to each other on sides of the respective narrower surfaces of said laminates through adhesive.